Assessing transformational change from institutionalising digital capabilities on implementation and development of Product-Service Systems: Learnings from the maritime industry

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Abstract

Digitization is rapidly reshaping industries and economic sectors. It enables novel Product-Service Systems (PSS) that transform customer/supplier relationships and introduces new value propositions. However, while opportunities for novel types of PSS arise, it is not clear how digitization and the institutionalisation of digital capabilities, particularly within the customer organisations, may affect implementation of PSS, potentially leading to transformational changes in the customer organisation. This paper examines one such potential transformational change from three complementary viewpoints – the resource based, the dynamic, and the relational viewpoint. It does so through action research study in the context of the maritime industry, which is particularly attractive for PSS offerings. The research methodology comprised a two-step action research process, focusing on both digitization and PSS development and implementation. The main findings are that rather than facilitating procurement to co-development of PSS, institutionalisation of digital capabilities facilitated development of PSS by stakeholders internal to the company, and strategic co-development with external stakeholders. The new digital capabilities circumvented cost barriers associated with the procurement of services from external stakeholders, supported process standardization - to the expense of process innovation-, and transformed the network that delivered PSS by closing opportunity gaps for externally procured services. Furthermore, the uptake of digital capabilities highlighted the importance of cost estimation in making the customer more responsive to threats and opportunities.

1. Introduction and research gap

In a challenging and globalised market, companies strive to enhance their competitive advantage, in order to survive and eventually expand. To support their competitiveness and profitability, companies contemplate the development and procurement of Product-Service Systems (PSS). A PSS is a delivery system for advanced services, similarly to what a manufacturing system is to a product (Settanni et al. 2015) and is defined as "*an integrated bundle of products and services which aims at creating customer utility and generating value*" (Boehm and Thomas 2013). The research community has used a number of synonymous terms and concepts to describe the shift from a product orientation to a service orientation that PSS advocate, including "servitization" (Baines, Lightfoot, Peppard, et al. 2009), "service infusion" (Eloranta and Turunen 2015), "integrated solutions" (Brady, Davies, and Gann 2005) and "service transition" (Fang, Palmatier, and Steenkamp 2008).

In achieving this transition, digitization is central to PSS. Digital capabilities are critical enablers for service delivery (Chesbrough and Spohrer 2006) and an important element of various successful PSS business models such as the 'engine by hour of flight' from Rolls Royce, and the Retail-Care offering for refrigerators by Danfoss (Tan et al. 2010). Digital capabilities allow PSS supply chains to be responsive (Ardolino et al. 2016; Johnson and Mena 2008), thus facilitating PSS implementation and delivery.

Despite their promise and natural affinities, the combination of digitization and PSS does not constitute a guaranteed path to success. A growing body of literature warns against the risks from servitization (Neely 2009; Valtakoski 2016), the low returns from services (Suarez, Cusumano, and Kahl 2013; Gebauer, Fleisch, and Friedli 2005; Kastalli and Van Looy 2013), the lack of fundamental demand for specific PSS (Pagoropoulos et al. 2017) and the inability of PSS to successfully transform the business landscape (Pagoropoulos, Kjaer, and McAloone 2016). Moreover, the interplay between digitization and PSS is far from obvious. From their development (Tan et al. 2010; Wang et al. 2011; Mougaard et al. 2012; Kuo 2011; Garetti, Rosa, and Terzi 2012) and procurement processes (Bratt et al. 2014; Howard et al. 2016), to

operation (Kuo and Wang 2012; Kuo 2011; Garetti, Rosa, and Terzi 2012), and associated consumer practices (Santamaria, Escobar-Tello, and Ross 2016), PSS are complex and digitization adds yet another level of complexity and abstraction (Coreynen, Matthyssens, and Van Bockhaven 2016). Such an increase in complexity can lead to high life cycle costs for the engineered system (Suh 2003, p.25), when not enough is known about how manufacturers can effectively leverage digital means to increase their service offerings (Lerch and Gotsch 2015; Coreynen, Matthyssens, and Van Bockhaven 2016).

We argue that the same knowledge limitation can also apply to the customer perspective. The customers' perspective and engagement is important for the successful development and adoption of a PSS (Tuli, Kohli, and Bharadwaj 2007; Valtakoski 2016; Coreynen, Matthyssens, and Van Bockhaven 2016), as integrated solutions of products and services are shaped by customer network identity goals, goal management approaches, and constraints (Epp and Price 2011). As a result, literature on PSS and related fields suggest that, for PSS to succeed, intensive collaboration with customers is necessary (Story et al. 2016; Valtakoski 2016).

Digitization further reinforces the role of collaboration due to the need to communicate across the value chain (Nanry, Narayanan, and Rassey 2015). However, one can identify conflicting views on the role of digital capabilities in shaping PSS business models. On one hand, building digital capabilities can facilitate PSS business models. Adoption and success of PSS business models depends on the customers' prerequisite capabilities such as contracting skills, the existence of flexible budgeting systems, and the existence of analytical skills that can demonstrate the benefits from service strategy adoption (Baines and Shi 2015; Pagoropoulos et al. 2017). On the other hand, digital capabilities can also mitigate the need for external assistance. Digital transformation is reshaping the organisation to take advantage of valuable existing strategic assets in new ways (Westerman et al. 2011). Digital transformation is not a one-off application, but a strategic choice towards acquiring and embedding digital capabilities across the supply chain and technologies such as Artificial Intelligence, Internet of Things and Big Data (Pagoropoulos, Pigosso, and McAloone 2017). And that transformation can preclude the involvement of external stakeholders for value

co-creation (Windler et al. 2016) and advocate a 'make' instead of 'buy' decision especially if digital capabilities have an impact on the customer knowledge base (Valtakoski 2016). As customers ramp up digital capabilities it is not clear how the collaborative network of stakeholders that develop and deliver the PSS is transformed, and how the individual contribution of each stakeholder in the collaborative network is redefined. To address this knowledge gap, this study is conducted within the context of the maritime industry. The maritime industry, due to the long life time of the ships and the existence of multiple non-critical systems presents attractive opportunities for PSS (Aston Centre for Servitization Research and Practice 2013; Mougaard et al. 2013; Andersen, McAloone, and Garcia I Mateu 2013). Building on this opportunity, this study poses the following research question and proposition:

Research Question: *How does the institutionalisation of digital capabilities in the customer organisation affect the implementation of Product-Service Systems in the maritime industry?*

Research Proposition: *The digitization of business processes institutionalises digital capabilities within traditional customer organisations, which in turn reveal opportunities for procurement and co-development of Product-Service Systems.*

The unit of analysis for the research conducted is the change process within an organization that traditionally procures products and services to support the cost-effective operations of its assets. As such, it covers the entire network of internal and external stakeholders that collaborate to offer a PSS. This study had three main objectives: to implement PSS that address customer needs and achieve business goals, develop the necessary digital tools and capabilities to deliver and support the PSS and understand how digital disruption is shaping power dynamics (Vendrell-Herrero et al. 2016; Lerch and Gotsch 2015), in particular within collaborative networks that deliver PSS (Mougaard et al. 2012).

We acknowledge that the answer to the research question depends on the perception of change, the evaluated sources of competitive advantage and the research paradigm from which the analysis is conducted (Tronvoll et al. 2013; Eloranta and Turunen 2015). In this study, the pathway between digital capabilities and PSS is evaluated from three distinct viewpoints, all of which stem from strategic management theory: a Resource-based Viewpoint (RBV) emphasizing the role of resources and capabilities, a Dynamic Capabilities Viewpoint (DCV) encapsulating the evolutionary nature of resources and capabilities, and a Relational Viewpoint (RV) focusing on the network relationships within which the firm is embedded.

In contrast to significant body of PSS and servitization literature that perceives services as an instrument for market positioning by 'going downstream' viewpoint was not examined (Vandermerwe and Rada 1988), this viewpoint is not examined in this study due to a lack of supply chain repositioning.

The research question follows suggestions from extant literature to examine the need for support towards the customer to develop the resources and capabilities to fulfil the co-creation role (Windler et al. 2016). Moreover, it explores the division of labour between suppliers and customers in PSS (Valtakoski 2016), and help explore future avenues for customer integration (Coreynen, Matthyssens, and Van Bockhaven 2016). Lastly, it adopts a novel perspective within PSS by exploring an instance where a service-minded customer can act as a provider and a resource integrator for PSS.

Section 2 reviews prior literature to establish the research proposition that acted as a point of departure for this study. Section 3 introduces the research context and the methodology that was followed. Sections 4 and 5 present the results of the study, and Section 6 discusses the findings and compares them to the literature. Finally, Section 7 summarises the conclusions and presents avenues for future research.

2. Prior literature

2.1. Digitization and PSS

Digitization is transforming existing business models, by unlocking new sources of value from existing technology. Digital transformation is attracting a lot of attention across different industries, as digital advances such as analytics, mobility, social media and smart embedded devices to change customer relationships, internal processes, and value propositions (Westerman et al. 2011). Even in traditional industries such as the automotive, digital technologies that enable connectivity between physical assets are altering user preferences (McKinsey & Company 2014) and driving new product and service developments (Mosquet et al. 2014). According to the Ellen McArthur foundation this "*increase in connectivity can create significant new sources of value for citizens and economies, whilst also creating new challenges for regulators and policy makers*" (Morlet et al. 2016). Across all industries, various reports highlight the transformational role of digital technologies, that is actively causing companies to re-think their role and value proposition (DNV - GL 2016; KPMG 2013; Manyika and Chui 2015).

Existing research has recognized the importance and opportunities that digital technologies hold for PSS and related fields. PSS enable and introduce innovations (Kjaer et al. 2016), either through their process or technology orientation. Moreover, servitization and PSS literature emphasize the role of technology orientation as the primary driver within the transition from basic to advanced services (Baines, Lightfoot, Benedettini, et al. 2009; Eloranta and Turunen 2015; Aston Centre for Servitization Research and Practice 2013). In service systems technology becomes a critical resource for value co-creation, service innovation and systems (re)formation (Akaka and Vargo 2014). Lerch and Gotsch (2015) further support that the interaction between digitization and servitization is considered very strong. while Chesbrough and Spohrer (2006) argue that the exploitation of information technologies is one of foundations of services science. Several empirical studies have explored the role of digital technologies on PSS development and implementation from the provider perspective. According to Opresning et al (2013) data collected from consumers during the PSS usage and then exploited on an ecosystem level could represent a new revenue stream for manufacturing enterprises. The stream of data can help PSS providers improve and retain a

competitive advantage. Ulaga (2011) argues that customer process data can enable suppliers to design and sell value-added services that assist customers in gaining productivity improvements and cost reductions in their own operations, while according to Lerch and Gotsch (2015), data can shorten innovation cycles and trigger incremental innovation in the short run.

Lastly, various authors have taken a closer look on the interaction between specific technologies and servitization and PSS. Opresnik and Taisch (2015) argue on the importance of big data for servitization, supporting the claim that Big Data can help manufacturers differentiate themselves and provide a competitive advantage. Scherer et al. (2016) discuss the use of Business Analytics in PSS design, arguing that Business Analytics can enrich the ideation process. Moreover, Business Analytics can help PSS designers understand their customers and create new sources of revenue. Lerch and Gotch (2015) propose the digital brain stage, where the physical and the intangible part of the PSS are integrated. The authors argue that the digital brain enables long term competitive advantages in the form of life cycle cost and availability guarantees, while information that is fed back to R&D can drive development efforts. Baxter et al. (2009) corroborate this point, as they argue that condition based maintenance and intelligent monitoring allow manufacturers to leverage the development of their products' functionalities to offer PSS.

2.2. Competitive advantage in PSS

Literature in PSS, and especially after 2006, has shifted its focus from the sustainability to the business potential of PSS (Tukker 2015). By paying closer attention to business management literature, researchers within PSS have evaluated ways in which the adoption of PSS can lead to a competitive advantage. According to Eloranta and Turunen (2015) competitive advantage in service literature can be analysed from four distinct strategic viewpoints: a market forces viewpoint, a Dynamic capabilities viewpoint, a Resource-based viewpoint and a Relational viewpoint.

A Market forces viewpoint evaluates the influence of market dynamics and strategic choices in acquiring and maintaining a competitive position (Porter 1980; Eloranta and Turunen 2015). Influenced by the

seminal work by (Vandermerwe and Rada 1988), PSS literature has evaluated how can the provision of services help improve company's position in the value chain (Tukker 2015). Various authors see PSS as method for companies to make use of market forces, including the growing importance of sustainability concerns in both Business to Business (B2B) and Business to Consumer (B2C) markets, the diminishing importance of product ownership and the advent of contractual requirements for availability (Bonini and Swartz 2014; Ceschin 2013; Datta and Roy 2010; Howard et al. 2016).

A Dynamic Capabilities Viewpoint (DCV) focuses on the dynamic reconfiguration of internal and external competencies. The Dynamic capabilities viewpoint encapsulates the evolutionary nature of resources and capabilities, arguing that value is created by implementing processes that are simple and achieve real-time knowledge creation (Wang and Ahmed 2007). The long term competitive advantage is achieved by using those processes sooner, more astutely, more fortuitously that the competition to create advantageous resource configurations (Eisenhardt and Martin 2000). Dynamic capabilities are an important source of competitive advantage in PSS. According to Belvedere, Grando, and Bielli (2013) responsiveness is the main driver of value creation in service-oriented organisations, and one that enables companies to identify and utilize opportunities. Fischer et al. (2010) argue that the development of dynamic capabilities occurs gradually. Based on an explorative multiple case study, they argue that in manufacturing organizations development of service capabilities starts from simple services on the installed base to more advanced maintenance and R&D services, with spare parts provision acting as a bridge between service and product businesses. Furthermore, a number of studies argue that PSS can enable more responsive organisations leading to smaller reaction times and ultimately better resource allocation (Amaya, Lelah, and Zwolinski 2014; Lelah, Mathieux, and Brissaud 2011; Xing, Wang, and Qian 2013). One particular dynamic capability that is recognised as essential to the survival of servitized companies (Roy and Cheruvu 2009) is cost estimation. Since cost in an important part of the value proposition of PSS (Baines, Lightfoot, Peppard, et al. 2009), successful cost estimation leads to cost consciousness. Cost consciousness in turn enables companies identify opportunities for change (Eisenhardt and Martin 2000) and seize service opportunities

(Fischer et al. 2010), as it connects actions to their economic implications (Settanni, Thenent, and Newnes 2013; Settanni et al. 2014).

A Relational Viewpoint (RV) is levering inter- and intra-firm linkages, arguing that competitive advantage is a result of the joint contributions of collaborators within the service ecosystem (Eloranta and Turunen 2015). According to Tuli et al. (2007), implementation of integrated products and services can only be successful because both suppliers and customers deploy them, not just because a supplier offers them. The argument is corroborated by Chesbrough and Spohrer (2006), who postulate that in services each party needs the other's knowledge in negotiating the exchange. Various authors (Lavie 2006; Story et al. 2016; Ceschin 2013; Mougaard et al. 2012) have identified that on the network as a source of strategic advantage. The importance and contribution of each stakeholder depends on the relative position in the network (Möller and Rajala 2007), while the structure of the network also depends on the complexity of the service offering (Kohtamäki et al. 2013).

A Resource-basedViewpoint (RBV) focuses on resources and technology orientation. According to RBV, firms sustain competitive advantage by acquiring resources that are valuable, rare, inimitable and difficult to substitute, where resources include assets, capabilities, organizational processes, firm attributes and knowledge (Barney 1991). According to Reim, Parida, and Örtqvist (2014) PSS literature has had a particular focus on the development of operational capabilities that can help companies innovate, and develop products and services that perform better and are easy to maintain. One area of focus in PSS is how to leverage and integrate technologies to innovate and eventually formulate new products and services (Manzini and Vezzoli 2003; Aurich, Fuchs, and Wagenknecht 2006). Coreynen, Matthyssens, and Van Bockhaven (2016) further argue that a successful transition to PSS hinges on the configurational character of the resource base.

2.3. Value co-creation through collaborative networks in PSS

Taking a closer look at the Relational viewpoint, the integration of products and services in PSS business models calls for a Service Dominant logic perspective for value creation (Kowalkowski 2010; Vargo and Lusch 2008). Such a perspective affirms the importance of network capabilities for both providers and customer, as the locus of value creation, moves from the "producer" to a collaborative process of value co-creation between parties (Vargo and Lusch 2008). In practice, a broad network is paramount in delivering PSS (Mougaard et al. 2012; Ceschin 2013), as the network of external stakeholders plays a significant role in shaping the resource-based competitive advantage of the customer organisation that delivers the PSS (Lavie 2006). In particular, network capabilities are often a prerequisite for external stakeholders, since they enable customer value creation (Berghman, Matthyssens, and Vandenbempt 2006) and facilitate transition towards PSS (Story et al. 2016). By conceiving value creation in the context of systemic business networks, firms can find opportunities to improve their effectiveness and adaptability (Kohtamäki et al. 2013). Möller & Törrönen (2003) argue that the development of new services often takes place through mutual investments and adaptations among the supplier, the customer, and other actors in the business network. By conceiving value creation in the context of systemic business networks, firms can find opportunities to improve their effectiveness and adaptability (Lusch, Vargo, and Tanniru 2010).

However, PSS are not simply delivered by a group of external stakeholders, as stakeholders internal to the customer organisation are also critical to the success of PSS. Service Dominant logic recognizes a fluid alteration between those resources that are internal to the customer organisation and those that are external, as both need to collaborate for PSS delivery (Kowalkowski 2010). Service exchanges invite a relational view (Eloranta and Turunen 2015), that require far-reaching cooperation between the suppliers and customer (Helander and Möller 2007). Previous empirical research has emphasised the importance of internal resources for PSS development and delivery (Pezzotta et al. 2016; Boucher 2012). In their analysis of servitizing Small and Medium Enterprises (SMEs) in Sweden, Kowalkowski, Witell, and Gustafsson (2013) identify that network business models can exhibit configurations that necessitate close cooperation with internal resources to deliver value. This close cooperation is, in many cases, necessary in order to

successfully navigate the political and operational difficulties within customer organisation (Tuli, Kohli, and Bharadwaj 2007). Moreover, it is a source of competitive advantage in itself, since it is a quality that can be very difficult for competitors to replicate (Kowalkowski 2010; Vargo and Lusch 2008). Furthermore, close cooperation ensures that development process is driven by customer insight, while focusing on customers' processes and financial drivers, not only on technological innovations (Storbacka 2011)

Collaboration is not the only option though. Internal stakeholders that are involved in service delivery can also be in competition with external stakeholders. Empirical studies provide evidence that the use of internal markets, where subunits of a firm buy and sell goods or services among themselves, is increasing (Egelhoff and Frese 2009). Moreover, PSS literature argues that in cases where PSS fit internal competencies (Cook et al. 2012) or the PSS has long-term strategic importance to the organisation (Aston Centre for Servitization Research and Practice 2013), the internal market can be an obvious candidate for PSS implementation. Compared to external resources, internal resources exhibit specific strengths that can provide them with a competitive advantage. Internal resources can make use of existing communication channels, are not required to make profit from service delivery and tend to be closer to the real needs of the business (Slack, Chambers, and Johnston 2007, p.154). This can enable internal functions to assume the role of social institutions, a position that enables them to be especially effective in delivering services such as training (Doeringer and Piore 1971). It should be noted though that internal resources suffer from limitations. Compared to external resources, they might strive to achieve economies of scope and scale (Arias-Aranda, Bustinza, and Barrales-Molina 2011; Michelini and Razzoli 2004), and at the same time run some risk of complacency due to lack of market pressure (Slack, Chambers, and Johnston 2007, p. 154). Involving external stakeholders might be absolutely necessary in case of complex advanced services, where customers have high expectations from a service that they cannot deliver on their own (Kohtamäki et al. 2013). In light of the multiple service network configurations involved in delivering a PSS, the question of whether to look towards the internal or the external market is not a dichotomous choice, but rather reflects a continuum with different degrees of involvement between internal and external resources. And

despite its importance though, little research exists on how the transition to PSS affects the organisational boundary between the solution provider and the customer (Valtakoski 2016).

3. Research context and methodology

Reflecting on prior literature, we can deduce that digitization and the uptake of digital capabilities can transform business processes, eventually creating competitive advantage. When used to formulate PSS, digital capabilities can lead to a competitive advantage, which can improve the companies' market position, enable responsiveness, alter the resource configuration and shape the collaborating network. Prior literature highlights the importance of the combined network of internal and external stakeholders, meaning that PSS are not only procured from a part of the network, but also developed in collaboration. Against this backdrop, and towards answering the research question, the following research proposition was used as a point of departure for this study:

Research Proposition: *The digitization of business processes institutionalises digital capabilities within traditional customer organisations, which in turn reveal opportunities for procurement and co-development of Product-Service Systems.*

3.1. Research context of the maritime industry

The maritime industry is one of the most internationalized industries (Lun, Lai, and Cheng 2010, p.1) and accounts for approximately 90% of the global trade (United Nations Conference on Trade and Development 2013).

The maritime industry shares similarities with traditional manufacturing industries. Suppliers to the maritime industry are serving several industrial networks, with many of the most established Original Equipment Manufacturers (OEMs) serving land based segments as well (Hameri and Paatela 2005). However, there are also important differences. Vessels are always at sea and spend most of the time spatially isolated from product and service supply chains. Therefore, the responsibility for everything that

happens on board rests with the crew. Thus, there are practical constraints on the level and frequency of support that land-based operations can offer. Moreover a significant portion of the global merchant fleet is trading in the tramp shipping business (Stopford 2009), where vessels operate without a fixed schedule, carrying available cargoes between any two ports. Their schedules are dictated by economics of supply and demand (Lun, Lai, and Cheng 2010; Stopford 2009) which often lead to irregular trading patterns and difficulties in long term planning.

The long life cycle of the ships, the capital-intensity of the industry, combined with the relative immaturity of PSS offerings (Kjær et al. 2015; Andersen, McAloone, and Garcia I Mateu 2013; Hameri and Paatela 2005) present opportunities for both suppliers and customers to explore and eventually implement servitized business models. PSS as a value proposition in the maritime industry has been the focus of previous research endeavours, most notably PROTEUS (Mougaard et al. 2013). Shipowners are central actors in the maritime industry, with high degree of involvement throughout the whole lifecycle of the ship, from procurement and production to operation and recycling (Kjaer et al. 2015). In this study the main case company is a shipowner, offering an integrated operational platform that incorporates both commercial and technical management of a fleet of product carriers. The fleet consists of a mix of both owned and leased vessels (commonly known as bareboat charters), and operates in the tramp shipping business. The company encompasses a broad range of internal competencies: from crewing and trading, to technical management and vessel IT support.

3.2. Research methodology

As previously discussed, studies of the PSS business model implementation process and the organisational changes that they trigger are called for. We believe the social engagement of the PSS implementation process and the radical transformations that the process incurs (Martinez et al. 2010; Reim, Parida, and Örtqvist 2014) invites participatory research designs, most notably by means of action research (Baum, MacDougall, and Smith 2006). Action research has its roots in social sciences (Lewin 1946) and is popular in

management research (Brookes et al. 2007). Action research differs from other research methods in that it seeks to bring about positive change, not simply investigate or describe an issue, as activities undertaken by the researcher are part of the stories of action research (Melrose 2001). The type of research performed was participatory in nature (Raelin 1999), as activities were a result of collaboration between researchers and practitioners from the industry, who in many instances become co-researchers themselves (Melrose 2001). The duration of the study was 95 weeks, and the primary data being collected were written documentation either through emails or minutes from meetings. Audio recordings, although employed in some cases e.g. during workshops or clarifications, were deemed impossible due to the constant interaction with different stakeholders. Integration into the action research process occurred through reflection and feedback. Reflection was facilitated by maintaining a journal and periodically discussing and comparing findings and observations. Feedback from was facilitated through newly established communication channels, project deliverables and participations in workshops and meetings. The researchers did not assume a passive role, but were actively influencing processes and activities in the company, helping the participating companies achieve their common goals (Coughlan and Coghlan 2002). The active involvement ensured a longitudinal view of the transformation process and privileged access to people and information, as organization members saw that the research project contributed to organizational learning and effectiveness. To ensure mutual understanding and transparency, the key observed constructs that comprised the main results of the project, together with the anonymized supporting statements were verified with participants during the formulation of the final report.

Lastly, the research process considered multiple viewpoints to analyse the PSS development and implementation process, and how it leads to a competitive advantage. Three complementary viewpoints were adopted: a Resource based Viewpoint (RBV), a Dynamic capabilities viewpoint and a Relational capabilities Viewpoint. In overall, we chose this heterogeneity of approaches, in an effort to avoid biases (Eloranta and Turunen 2015), and understand the nature of services as activities and interactions (Tronvoll et al. 2013). The focus was on a network of collaborating stakeholders delivering a PSS to a group of

internal customers, as shown in Figure 1. Over the course of the study, the three viewpoints were used to maintain a direction for the action research, compelling researchers and participants to reflect on how PSS can enable responsiveness, alter resource configuration, and shape the collaborating network. The market positioning viewpoint was not examined, as repositioning in the supply chain did not occur and was thus outside the scope of the study.

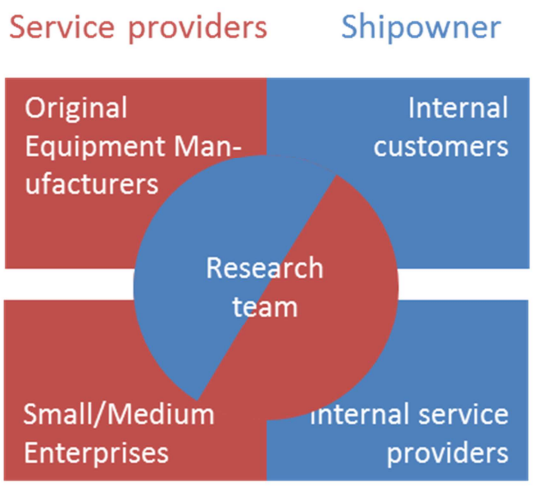

Figure 1: Network of collaborating companies involved in PSS implementation in this study. The research team was primarily involved in facilitating and evaluating the interaction among the different stakeholders

3.3. Motivation and PSS description

The motivation for the project was the need to improve the way in which the customer company's assets were managed, as mid- and senior level management recognized the need for data driven decision making. Performance management is a core area of digitization transformation that enables performance transparency, thus empowering decision makers by allowing them to make more informed decisions (Westerman et al. 2011). The result was a PSS focused on the performance management for tanker vessels, and applied to all the vessels (both owned and leased) under technical management. The main areas of focus were (1) power management, (2) consumables, (3) internal process compliance related to operation of equipment and (4) condition monitoring of specific equipment.

The developed PSS monitored a group of high and low level Key Performance Indicators (KPI). In the area of power management, an example of a high level KPI is the efficiency of the generator engines as measured by the Specific Fuel Oil Consumption (SFOC), while an example for a low level KPI is the running hours of electrical consumers such as sea water pumps. A technical description for the analysis of power management can be found in (Pagoropoulos, Møller, and McAloone 2017), explaining the use of Artificial Intelligence (AI) for power management on board the vessels. Figure 2 shows the principal information flows, together with the involvement of the action research processes.

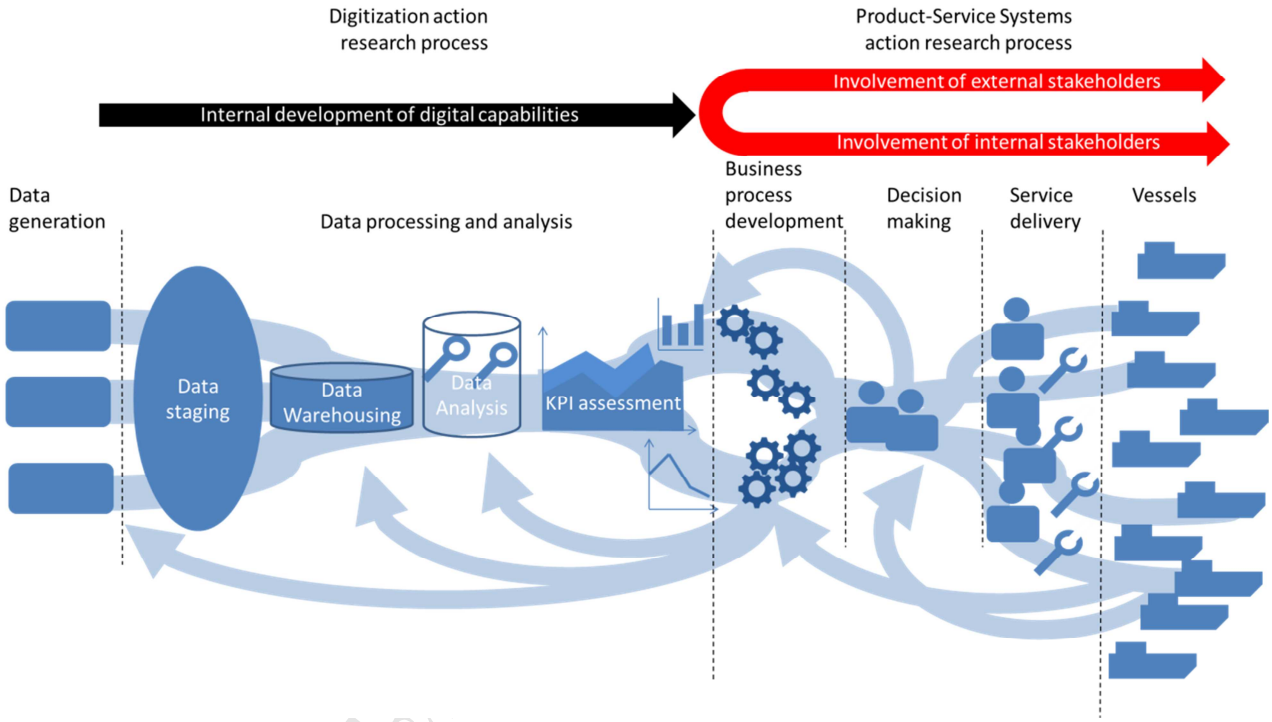

Figure 2: Information flows and involvement of the action reseach process

The process flow consists of two process streams: a digitization stream that is IT-driven and extracts information with business value from the available data in a clear and systematic way, and a PSS stream that is business-driven, utilizes the extracted information and provides feedback. Although the two flows were not independent and were interacting with each other, the relied on a different technical background, and were thus studied separately. The PSS stream bifurcated into two parallel streams to juxtapose the activities of the internal with the activities of the external stakeholders.

Looking at the process in detail, the starting point was the different information platforms used by the various departments within the company. It is in those platforms where data is generated in the day-to-day operations of the business. Data from those systems was collected, processed and analysed, and fed into the company KPI structure. Afterwards, the produced information was utilized for business process development. Business process development was arguably the most reflective step of the process. In this phase KPIs were interpreted and evaluated, and business logic and data processes were maintained and redesigned. Based on an overview of the needs and shortcomings of the organisation, a roadmap was delineated for internal process alignment that included establishment of new communication channels and collaborations, and development of Standard Operating Procedures (SOPs). Moving downstream in the information flow, business process development focused on strengthening coordination among stakeholders, striking the right balance between digital and physical communication.

Decision making was where mid- and high level management was involved. Based on assessment of Key Performance Indicators (KPIs) and support from business process development, action plans were formulated. The last step of the process was service delivery. In service delivery actions materialized and vessels were actively approached. Service delivery encompassed both physical service delivery such as vessel attendance and training courses, and remote assistance supported by digital means including emails, reports etc.

4. Results of action research towards the institutionalisation of digital capabilities

The digitization action research process focused on providing the necessary digital tools and capabilities for data-driven performance management. In the initial phases of the digitization action research process, the researcher were involved in development efforts including requirement gathering and prioritization, definition of success criteria, prototype and final solution development, and finally development of data interfaces and associated KPI dashboards. The development process followed a Phase-Gate project

management process, based on processes and templates from (Sherman 2014). As projects and activities gradually became more standardised, the role of the researchers changed to supporting digital infrastructure and refining digital capabilities.

Data processing and analysis. Data processing and analysis relied primarily on business logic delivered by means of Business Intelligence tools, combined with Artificial Intelligence for data analytics. Business Intelligence (BI) is a broad concept that encompasses a wide range of tools and functions: from data collection and Data Warehousing (DW), to data analysis and knowledge management. The goal of business intelligence is to extract business value from the data that is stored in the business systems that every organisation has accumulated over the years (Janus and Misner 2011; Sherman 2014). A detailed presentation of the BI environment and its technical aspects is outside the scope of this article. What is relevant to describe though are the digital capabilities that the BI system enabled, as they are central in highlighting opportunities and evaluating the cost impact of implemented PSS. The developed platform enabled data integration and processing across multiple systems and platforms, merging data across information silos while covering virtually every department within the organisation. The process resulted in information that is clean, consistent, comprehensive and conformed, which enabled further analysis and deeper insights. Finally, the processed data were feed into the KPI structure, ensuring that information is available across the customer organisation.

5. Results of action research towards PSS development and implementation

5.1. Involvement of internal stakeholders in PSS implementation

For the internal stakeholders, the PSS action research process focused particularly on creating processes that utilize the developed tools and capabilities in performance management. Understanding that PSS and a data driven mentality were novel to the company, there was a need for a more gradual development and implementation. The researchers' role was to create internal processes to share data and findings. Regarding data collection, qualitative data was collected through a series of approximately 80 interviews

with relevant stakeholders. Most the interviewees were mid-level managers, and occasionally technical experts and top management. The interviews were complemented by three workshops where the developed PSS, together with its goals and value proposition, was presented to internal stakeholders. Individual statements and conclusions from meetings were collected in minutes and discussed with key participants. Quantitative data were collected and analysed through the digitization action research process described earlier. Lastly, the identified constructs were compared against the actual KPI patterns to establish a causal understanding on developments, particularly those stemming from the implementation of the PSS

Finally, PSS implementation was discussed in focus groups including technical experts, mid-level managers and active seafarers. The goal of those focus groups was to determine the best course of action towards capturing cost savings. Afterwards, the PSS was further developed by creating feedback loops and establishing reverse information flows, in accordance with standard practices in action research (Hayes 2014, p.336). To create shared ownership of the results and address the needs of the internal customers. for a period of approximately 30 weeks the researchers held regular monthly meetings with internal customers on performance trends. During those meetings, the results of the data analysis were discussed, methodological issues were clarified and further areas of interest were delineated.

Business process development. Digital capabilities were primarily used for process and cost control, as they enabled performance transparency. They mitigated the need for external help, as internal stakeholders naturally adapted to the new opportunities. Internally developed tools could deliver the same functionalities as commercial off-the-shelf platforms, and in the words of a technical manager "*It doesn't make sense to pay for external people all the time, especially if we can do it ourselves*". The same internal capabilities facilitated process standardisation, especially when they facilitated communication and agreement across the different departments of the company.

Decision making. Decision making focused on establishing processes around recurrent problems and issues stemming from lack of basic planning, knowledge gaps or lack of organisational structures to support

reflective actions. For example, a number of vessels were consistently flagged as a poor performer in terms of power management, as the analysis of consumption patterns revealed a consistent discrepancy between the expected and the actual energy consumption. Further investigation attributed the poor performance to sub-optimal start and shut down procedures. Lastly, performance transparency activated new communication channels. For example, in some cases crews would start sharing knowledge and best practices, especially when they sailed on vessels with a similar design where numbers could be easily compared.

Spearheaded by tangible cost improvements, PSS resulted in a reflectively informed decision making, which established their implementation within the customer organisation. It was important not to simply report on cost and KPI developments, but also establish a causal understanding towards the reasons behind cost improvements.

Service delivery. The identification of cost potentials enabled efficient utilization of existing resources and activities for service delivery. On one occasion, a vessel was consistently flagged as a poor performer in terms of power management, and the analysis of consumption patterns attributed the poor performance to inadequate process compliance. When the vessel was in dry dock for planned repairs, an experienced superintendent from the office that attended the repairs also expanded his activities to train the crew on proper start and shut down procedures, thus anchoring cost improvements with the people on board. Moreover, acting on the results of the analysis led to unexpected discoveries, triggering a deeper inquiry into the root causes and highlighting further opportunities within the organisation. For example, when analysing a set of low level KPIs that indirectly relate to power management on board, a particular vessel seemed to report excessive running hours of the generator engines. Further investigation revealed that this was not a stand-alone event, and revealed a deeper problem and a lack of process compliance. Had the problem not be corrected in time, it could lead to equipment failure, triggering further maintenance and insurance costs. This timely reaction prevented future losses and reinforced trust in the PSS. It should be noted that cost improvements from PSS implementation did not follow a straight and predictable line and

were not uniform. Some parts of the customer organisation were quick to react and captured cost savings immediately; others were more difficult to engage. This asymmetry meant that, in the big picture, improvements demanded constant focus, which materialised through incremental -rather than disruptive- changes. For example, the frequent crew changes created an ever-changing environment on board, which meant that vessels occasionally regressed to old practices.

5.2. Involvement of external network in PSS implementation

For the external stakeholders, the PSS action research process focused on complementing the existing digital capabilities portfolio and expanding performance management to cover further focus areas. The institutionalisation of digital capabilities revealed opportunities that required the involvement of external stakeholders for PSS development, especially where there were needs for competencies not present within the internal network. In regards to the discovery process of the external stakeholders, both OEMs and SMEs were considered. And just as with the internal network, there was a need for a gradual development and implementation together with the involved departments within the customer organisation. In those cases, the researchers' role was to share data and findings –both internally and externally- and connect external resources and competencies to internal processes. The researchers took preparatory meetings with the companies to assess their organisational readiness towards PSS. Collaboration was complemented by workshops and formal meetings, in an attempt align expectations and discuss goals, timelines, success criteria, and required deliverables.

Business process development. The result was collaborative activities that moved beyond simple service delivery to a long-term collaborative relationship. External resources acquired a strategic role and were primarily involved with business process development. In engaging external partners, an interesting observation was that small, service-oriented companies were easier to assume a strategic role.

For example, one key area of power management is the assessment of hull and propeller performance, as approximately 75% of the total fuel consumption on board is used for propulsion (Pagoropoulos, Møller, and McAloone 2017). Even though various turnkey solutions were available on the market, collaboration moved forward with a small expert organisation that could develop business support using existing information platforms. Moreover, and due to the collaborative development of business processes to support PSS implementation, the expert organisation gradually increased their scope from evaluation of the technical performance to also providing business support on commercial decisions. On the other hand, bigger organisations such as OEMs proved to be more constrained. The first constraint was the influence of their own internal processes. In the words of a sales engineer "*I have to go many levels up, even for a single service contract*". Moreover, the customer-defined scope required that they target areas, which in many cases were outside of their original area of expertise. In the words of business development manager for an OEM "*our core expertise is on electronic control system and [a specific component]. These are the areas where we can deliver the most value to our customers"*.

Decision making. Similarly to the internal market, there was a pronounced need to establish a causal understanding towards the reasons behind cost improvements. In the words of a business developer *"We want to see the feedback to argue on the effect of the joint project with the pilot vessel and include it in our [service offering]".* But unlike the internal network where costs were hidden, activities by external stakeholders incurred immediate costs. Due to high associated costs, it is necessary that external stakeholders are involved for a limited amount of time. In the words of a senior business manager from the customer organisation: "*Hiring an external consultant is expensive, especially if we start a project that lasts for half a year. We only take that decision as a last resort*". Moreover, these costs can create friction, especially in periods where budgets are tight. For example, in one pilot project a misunderstanding on division between costs and responsibilities unexpectedly escalated, as it threatened to put the technical department off budget for the quarter. Moving beyond these costs proved especially challenging in cases where knowledge limitations challenged the formulation of an action plan. For example, data analysis

revealed that some vessel types had a problem with the efficiency of the electric power system. The inefficiency was reflected in the low power factor of the power management system on board, and especially visible in cases where electrical motors on board were only partially loaded. As competencies on electronics are somehow limited in the customer organisation, the root causes of the problem and the potential cost improvement were obscure. Technical management had difficulties committing budget and resources to a problem it did not understand. And without financial commitment, it was difficult to actively involve external stakeholders, thus leaving potential savings uncaptured.

Service delivery. The involvement of external stakeholders in service delivery did not preclude the successful integration of their solutions in the co-developed PSS. For example, in an effort to improve the data quality of the PSS with regards to power management an automated fuel measuring system was installed on a group of vessels. The involvement of external stakeholders was limited to commissioning, with limited support in the implementation process and without guidance on how to extract business value from the new sources of information. In the words of a performance manager from the customer organisation: *"An installation engineer signed off that there was a signal, and that was it. They did not even make sure that the signal was correct"*. The measuring system found limited usage and as a result, installations were discontinued. But even for the vessels where it was successfully installed, the measuring system was not eventually integrated in the PSS. Even beyond this particular example, external stakeholders were always confined to a supporting role, as the implementation process was handled by internal stakeholders. In the words of a business developer *"we can provide you with tools and equipment, but it is up to you to educate your people on board".*

Lastly, the introduction of digital capabilities did not necessarily present an opportunity for external stakeholders to disrupt the existing business processes. Although data enabled advanced services, they were supplementary, as they did not eliminate the need for basic services. For example, when evaluating the transition from planned maintenance to condition-based maintenance on internal combustion engines,

a continuous data feed was an important improvement, but only one part of the final solution. Condition based maintenance did not eliminate the need for either quality control of the operating fluids (i.e. fuel, lube oil and cooling water), or monthly tests and visual inspections.

Moreover, delivering advanced services did not just depend on the appropriateness of the collected information, but was also contingent on factors related to the relational dynamic between internal and external stakeholders. A particular issue was data confidentiality, which meant that there were no guarantees as to how and if data could be transferred to external stakeholders. In the words of a business developer *"It might not be an issue with you [i.e. the customer organisation], but other customers are hesitant to share data".*

6. Discussion

The institutionalisation of digital capabilities affected the implementation of PSS on different levels. This section discusses their influence on the three viewpoints outlined earlier, namely the dynamic capabilities, the relational and the resource-based viewpoints.

6.1. Reflection on the Dynamic capabilities viewpoint

From a Dynamic capabilities viewpoint (DCV), digital capabilities influenced the internal and external stakeholders' capabilities to adapt, integrate, and reconfigure skills, resources and functional competences to respond to a changing environment. In particular, BI tools enabled statistical analysis of the organisational data and allowed extraction of up-to-date information for creating business value. Towards facilitating reactive data-driven decision making, cost savings were the primary determinant of the value of the implemented PSS. Costs were not just another KPI but the medium and the framework in which processes and activities were planned and evaluated. Looking at the internal/external stakeholder dichotomy, we witnessed that involving internal stakeholders proved more cost effective, provided they

had the right skills and capabilities. When involving external stakeholders, costs can be a critical barrier, especially in the early phases of a project and particularly during service delivery.

In creating actions and building a reactive mindset, cost estimation is an important skill and determinant of PSS adoption. Cost estimation enabled stakeholders to shape the internal political environment, draw management support based on insights from the data, and finally trigger actions during PSS implementation. A requirement for cost estimation is the establishment of causal mechanisms between costs and performance. Establishment of this link was necessary to communicate opportunities across the organisation and create awareness.

Looking at cost improvements stemming from the institutionalisation of digital capabilities, a rather unexpected result was that transformation was reactive and incremental– what Nadler et al (1995) refer to as 'adaptation'. The introduction of digital capabilities did not change the fact that cost improvements stemmed from the implementation of reactive processes that enable better planning, higher utilization of existing resources, implementation of best practices and quicker reaction times. The extent to which PSS, as enabled by digitization capabilities, took advantage of the opportunities at hand to support these goals essentially drove their adoption.

Reflecting on prior literature, it should be noted that this finding is only in partial agreement with previous studies in service literature and reports from the industry (Morlet et al. 2016; DNV - GL 2016; KPMG 2013; Manyika and Chui 2015; Vendrell-Herrero et al. 2016; Lerch and Gotsch 2015), which in turn argue on the disruptive effect of digital technologies.

At the same time, the findings of the study reaffirm the importance of cost estimation as a dynamic capability and a prerequisite for creating cost consciousness towards PSS. Digital capabilities facilitated responsiveness (Belvedere, Grando, and Bielli 2013), but that responsiveness was contingent on management support. Management support in turn depended on the existence, identification and realization of cost savings (Baines, Lightfoot, Peppard, et al. 2009). This study shows that digital capabilities, when they facilitate cost estimation, can enable value creation in PSS by improving the companies'

responsiveness to opportunities. Lastly, and in contrast to propositions in extant literature on the gradual application of dynamic capabilities in service organisations (Fischer et al. 2010), service innovations skipped the initial level of delivering services for the installed base, and focused on advanced maintenance and R&D oriented services.

6.2. Reflection on the Resource-based viewpoint

From a Resource Bbased Viewpoint (RBV), institutionalisation of digital capabilities influenced the value proposition of the implemented PSS. Business Intelligence (BI) and data analytics were seen as important sources of value when assimilated into business processes, enabling actions upon the findings that improved performance and results. The internal stakeholders took advantage of these tools to standardise processes, highlight areas of improvement and streamline the use of existing capabilities and resources, often without the need for external assistance. Moreover, standardisation of practices was necessary for delivering services through the PSS. We witnessed that the most successful innovations developed organically within standardisation initiatives through the newly acquired digital capabilities.

Although digital capabilities uptake in the customer organisation proved successful when standardising, they struggled to support disruptive innovation. In general, the introduction of new tools and concepts effectively undermined the standardisation process, as it created information asymmetries and introduced complexity to the system. Especially in cases where efforts to innovation preceded their inclusion in a PSS, those projects only enjoyed temporary success. This was an issue, particularly with the external stakeholders. External stakeholders acted as innovation agents that introduce new products and services that over time became a part of a PSS. However, their involvement did not preclude implementation. This limitation underlined the important role of the internal resources in successful PSS implementation as the primary drivers of standardisation.

Reflecting on the prior literature, various studies postulate the importance of technological innovations (Story et al. 2016; Chesbrough and Spohrer 2006). The focus on innovation contrasts the findings of this

study, which in turn highlights that it is important that in PSS stakeholders employ digital capabilities not only to reconfigure (Coreynen, Matthyssens, and Van Bockhaven 2016), but also to standardise business processes. Lastly, the study showed that internal stakeholders expand their competences as they acquire digital capabilities, thus eroding the uniqueness and inimitability of external stakeholders' resources and capabilities.

6.3. Reflection on the Relational viewpoint

From a Relational viewpoint (RV), the institutionalisation of digital capabilities within the customer organisation influenced the contribution of the collaborating stakeholders, effectively altering the collaborating network that delivered value through PSS. Internal stakeholders were the key beneficiaries from introduction of digital capabilities as transparency provided them with new communication channels and a higher level of process control. Thus, digital capabilities revealed a demand for services that could be delivered within the existing channels while utilizing existing resources. In a way, the institutionalisation of digital capabilities that "simplified" PSS implementation and delivery mitigated the need for a collaborative orientation. This resulted in a higher involvement of internal stakeholders, with a selective integration of strategic external resources. Digital capabilities on the customer side reduced the need for procuring physical services, as external resources assumed a more active role towards business process development.

Digital capabilities, and most notably Data Warehousing, consolidated the various information silos in the customer organisation, thus allowing scope expansion and system-wide perspective of problems and opportunities. This system wide perspective did not necessarily follow the competencies and product/service portfolio of any single external stakeholder. External stakeholders needed to collaborate to offer a broad service offering and fit the scope and needs of the customer. Moreover, we witnessed that the need for collaboration particularly favoured smaller companies. Due to their size, SMEs have fewer internal resources in terms of financing and skilled personnel compared with large firms. At the same time though, SMEs are likely to adapt to network configurations that are tailored to the needs of their

customers, which strengthens their customer and partner relationships and secures necessary capabilities for them (Kowalkowski, Witell, and Gustafsson 2013).

Reflecting on prior literature, collaboration between external and internal stakeholders supported a relational view of PSS (Eloranta and Turunen 2015). Findings are line with a relational view on solutions, which claims that PSS are effective because both internal and external stakeholders support them (Tuli, Kohli, and Bharadwaj 2007) In line with extant propositions from the literature opportunities (Lavie 2006; Story et al. 2016; K Mougaard et al. 2012), the collaborative network comprised a strategic advantage, as we witnessed that competitive advantage was gained through the joint idiosyncratic contributions of specific alliance partners and the service ecosystem. Moreover, the fact that services got simpler meant that a complex network to deliver services was no longer necessary. Thus, the contribution of external stakeholders in delivering the PSS is diminished. This finding is at odds with existing literature (Meier, Roy, and Seliger 2010; Kohtamäki et al. 2013), which argues that complex bundles of services and products represent opportunities for sales growth.

7. Conclusions

This study evaluated how the institutionalisation of digital capabilities in the customer organisation affects the implementation of Product-Service Systems in the maritime industry

The research proposition was partially disproven, as digital capabilities facilitated internal development and co-development with external stakeholders rather than procurement of PSS. The reason was that the institutionalisation of digital capabilities circumvented cost barriers associated with the procurement of services from external stakeholders, supported process standardisation - to the expense of process innovation- and transformed the network that delivered PSS by closing opportunity gaps for externally procured services. Furthermore, the uptake of digital capabilities highlighted the importance of cost estimation. In overall, digital capabilities favoured the internal network of stakeholders, especially in regards to service delivery, as the external network maintained an important role on strategic collaborations.

The present study built on prior literature to explore an emergent topic in PSS - i.e. the role of digital capabilities as an aftereffect of the ongoing digital revolution. The analysis from three distinct perspectives showed that digital capabilities can lead to a competitive advantage in distinct, yet complementary, approaches. Lastly, it adopted a novel perspective by exploring an instance where a service-minded customer can act as a provider and a resource integrator for PSS.

Reflecting on the limitations of the study, the main challenges stem from the nature of action research as a research method. Action research is an unrepeatable journey, one that cannot be replicated exactly (Melrose 2001). Moreover, as such, the applicability of the findings to other industries and settings is unclear. We believe that capital- and energy-intensive industries that share similar characteristics with the maritime - such as manufacturing or offshore- are likely to find the results more relatable. Another set of limitations stems from the position of the researchers. As action research necessitates the deep and active involvement, it can lead to a lack of impartiality, incentive misalignment due to the difficulties in jointly satisfying the twin goal of contributing to industry and academia and the dependency of the outcome on personal skills (Coughlan and Coghlan 2002; Melrose 2001). Such threats to research quality are difficult to mitigate given the emergent and unpredictable character of action research. In line with suggestions from the literature, the main remedies that were employed in this project to create academic rigor were a) the participatory pluralism character of research, b) systematic data collection and c) constant triangulation of data and information. Although not a panacea, such activities they helped contain sources of bias. Nevertheless, we need to acknowledge that a certain bias is still present, with certain perspectives and mechanisms dominating the results. Most notably, in the context of the study dynamic capabilities are driven exclusively by cost improvements, effectively ignoring other drivers and sources of value such as learning and organisational stretching (den Hertog, van der Aa, and de Jong 2010).

Digitization arguable opens new avenues for research. Future work could investigate the role of other digital technologies, and in particular the Internet Of Things (IoT) and Cloud Computing. Moreover, as this

study was conducted solely within the context of the maritime industry, future work could evaluate the role of digital capabilities on different industries and the Business to Consumers (B2C) market.

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Highlights

- Study of institutionalisation of digital capabilities on Product-Service Systems
- PSS co-development by both internal and strategic external stakeholders
- Digital capabilities supported process standardisation to the expense of innovation
- Digital capabilities closed opportunity gaps for externally procured services
- Digital capabilities highlighted the importance of cost estimation